



# Link and Routing Issues for Internet in Space

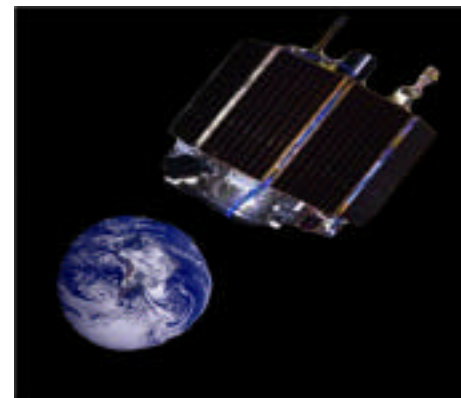
Operating Missions as Nodes on the Internet  
(OMNI)

<http://ipinspace.gsfc.nasa.gov/>

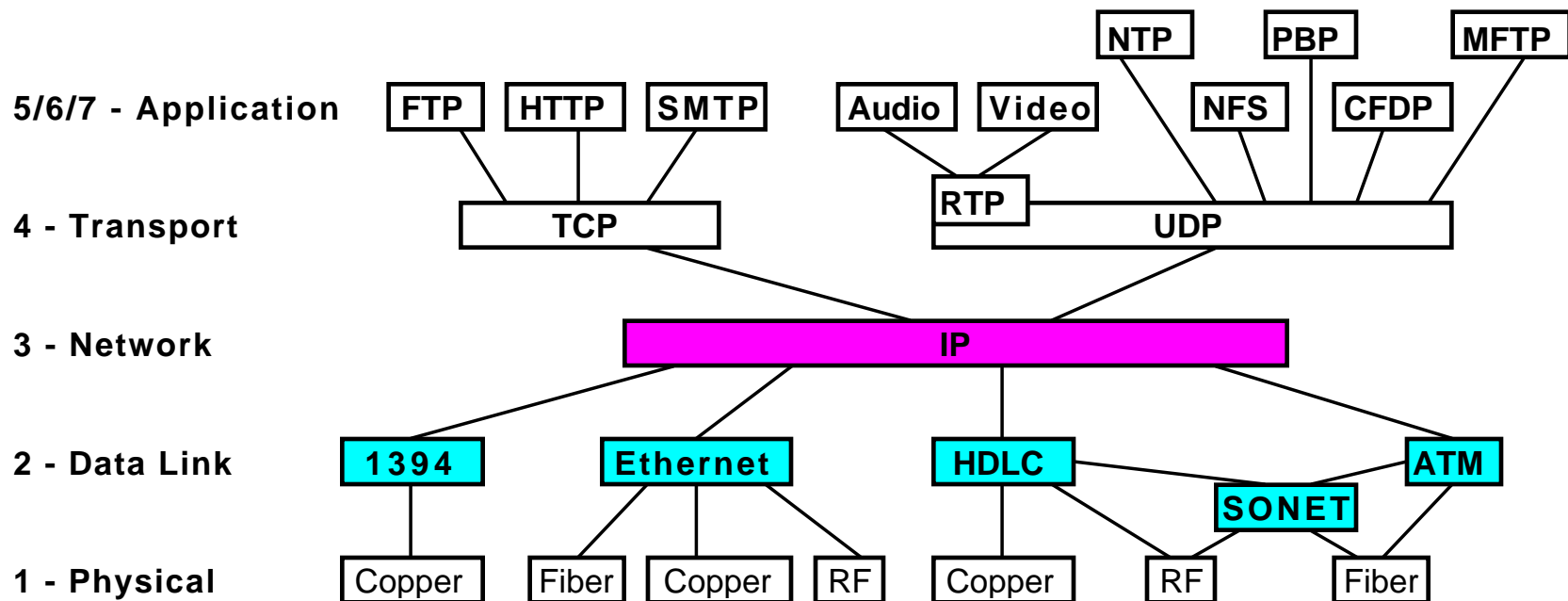


Keith Hogie  
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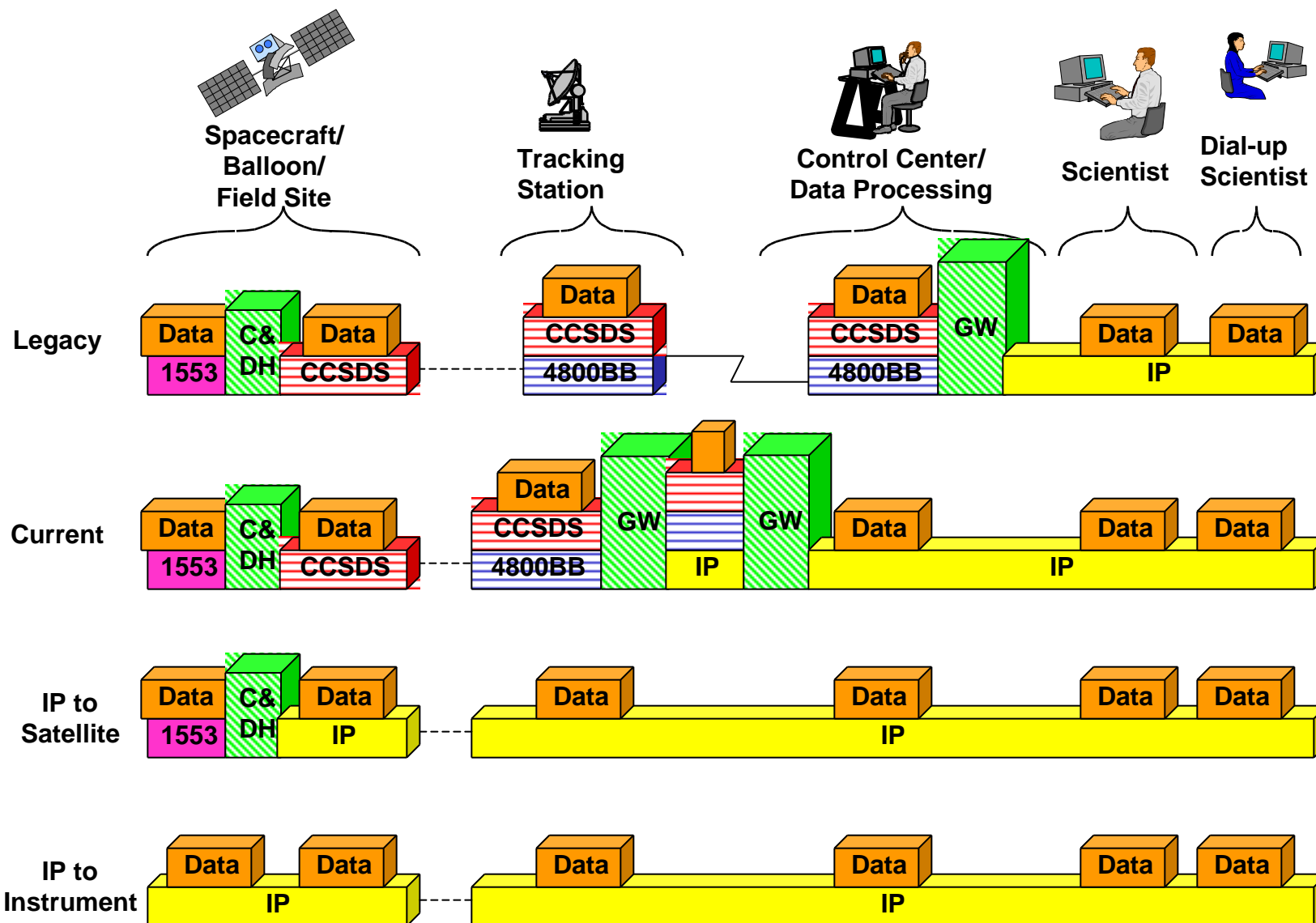
**Nov. 15, 2000**



- Internet Protocol (IP) hides data-link and physical layer details from upper layer protocols

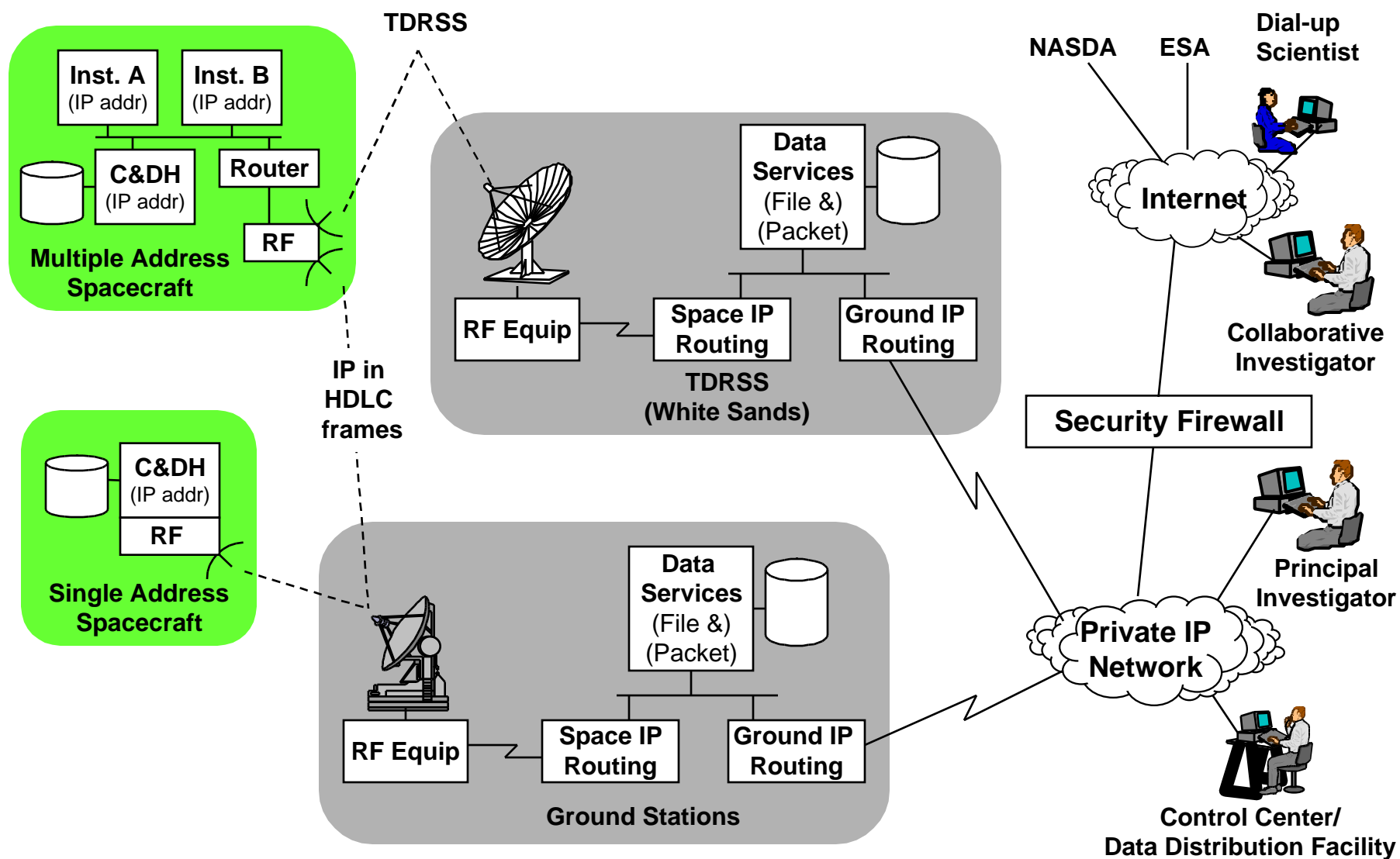
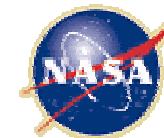


**IP is not TCP !!!**



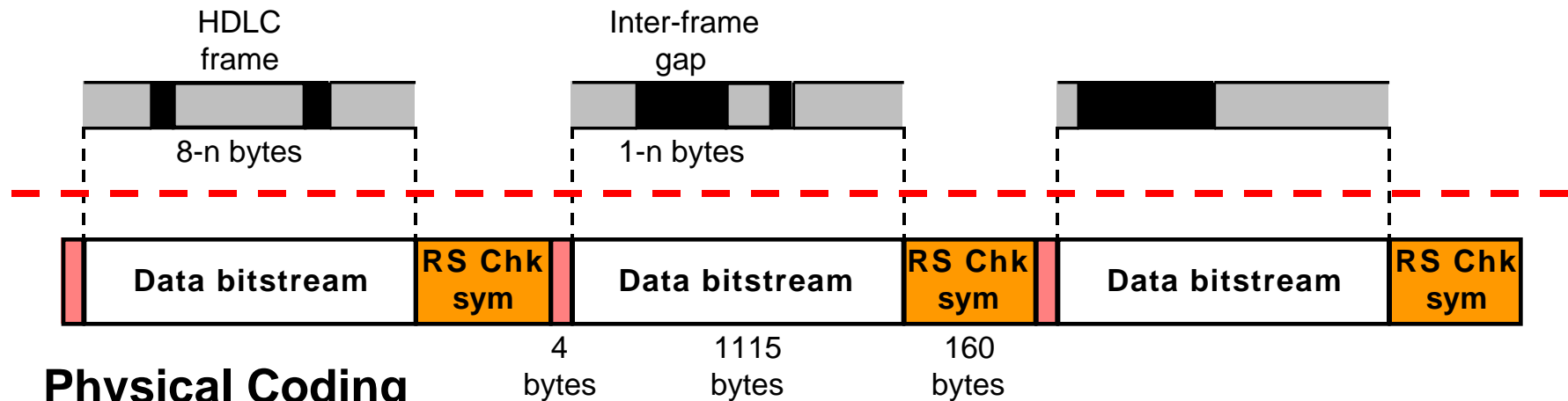


# Space Internet Implementation



## Link Framing

- Locate data frames
- Error check data frames
- Link level addressing



## Physical Coding

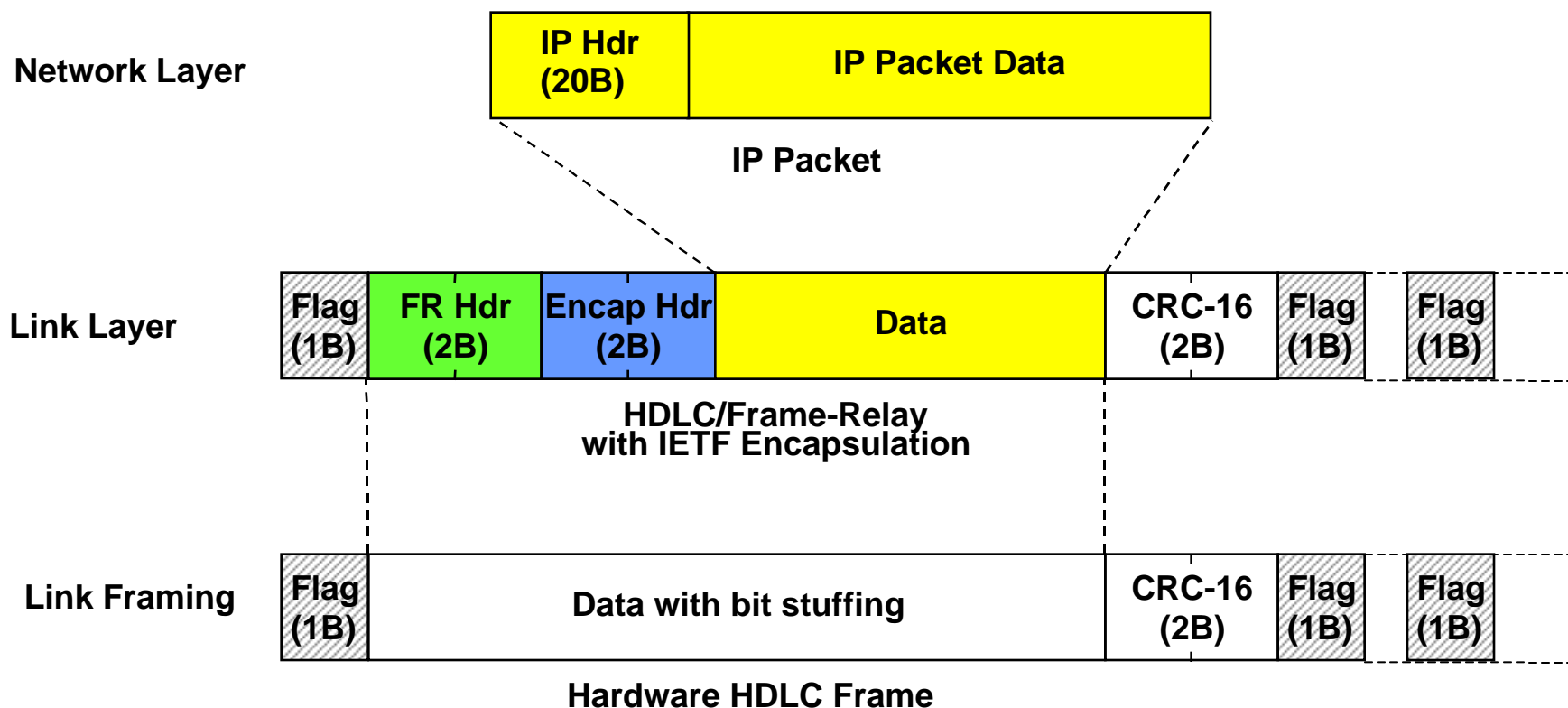
- RF mod/demod
- Up/down convert
- Bit sync
- Scramble/descramble
- Randomize/derandomize
- Convolutional encode/decode
- Reed-Solomon encode/decode



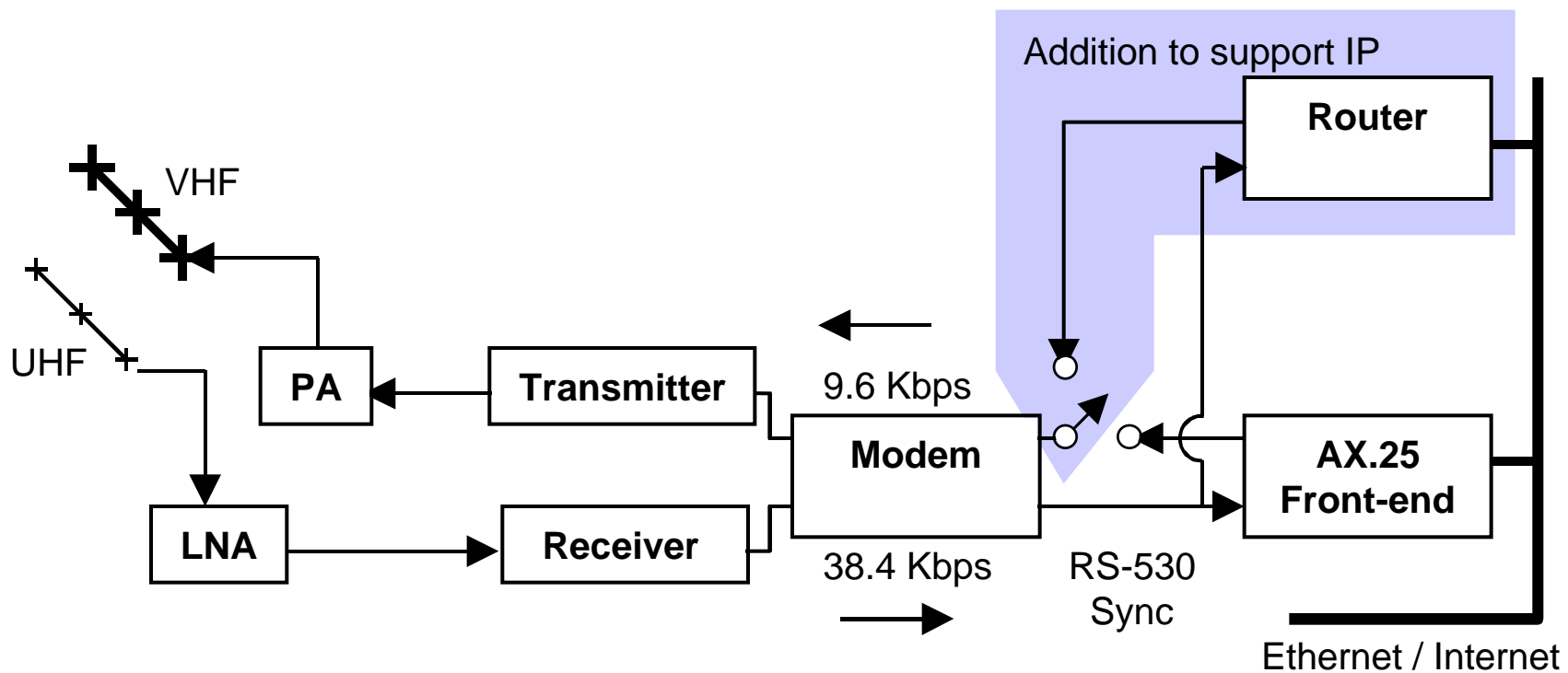
# Space Link Data Framing



- UoSAT-12 normally uses AX.25 (X.25 over HDLC)
- Internet tests used standard IETF Multi-Protocol over Frame Relay (RFC 2427 over HDLC)



- **Surrey Ground Station (SSTL)**
  - Installed Cisco provided router with RS-530 interface at SSTL
  - Interfaced router to clock/data from SSTL transceiver
  - Verified router receiving HDLC frames
  - Uploaded new SCOS modules to secondary CPU onboard UoSAT





# Onboard LANs



- **Eventually each spacecraft instrument may be on a LAN with an IP address**
- **Current LAN options being investigated**
  - IEEE-1355 (1-1000 Mbps)
  - IEEE-1394 (100, 200, 400 Mbps)
  - Ethernet (10, 100, 1000, 10000 Mbps)
- **Ethernet becoming major industrial LAN technology supporting real-time, deterministic environments**
  - Industrial Ethernet Association -  
<http://www.industrialethernet.com/>
  - Industrial Automation Open Networking Alliance -  
<http://www.iaona.com/>
  - GE Cisco Industrial Networks -  
<http://www.gecisco.com>





# Network Layer



- **The Internet Protocol (IP)**
  - Simple datagram delivery
  - Global, end-to-end addressing with a source and destination address on each packet
- **Fixed format protocol header - follow it exactly or you don't communicate**
- **IP hides the details of the data link layers from the upper layer protocols**
- **Standard programming interface (Sockets) simplify programming and transportable code**

**IP is not TCP !!!**



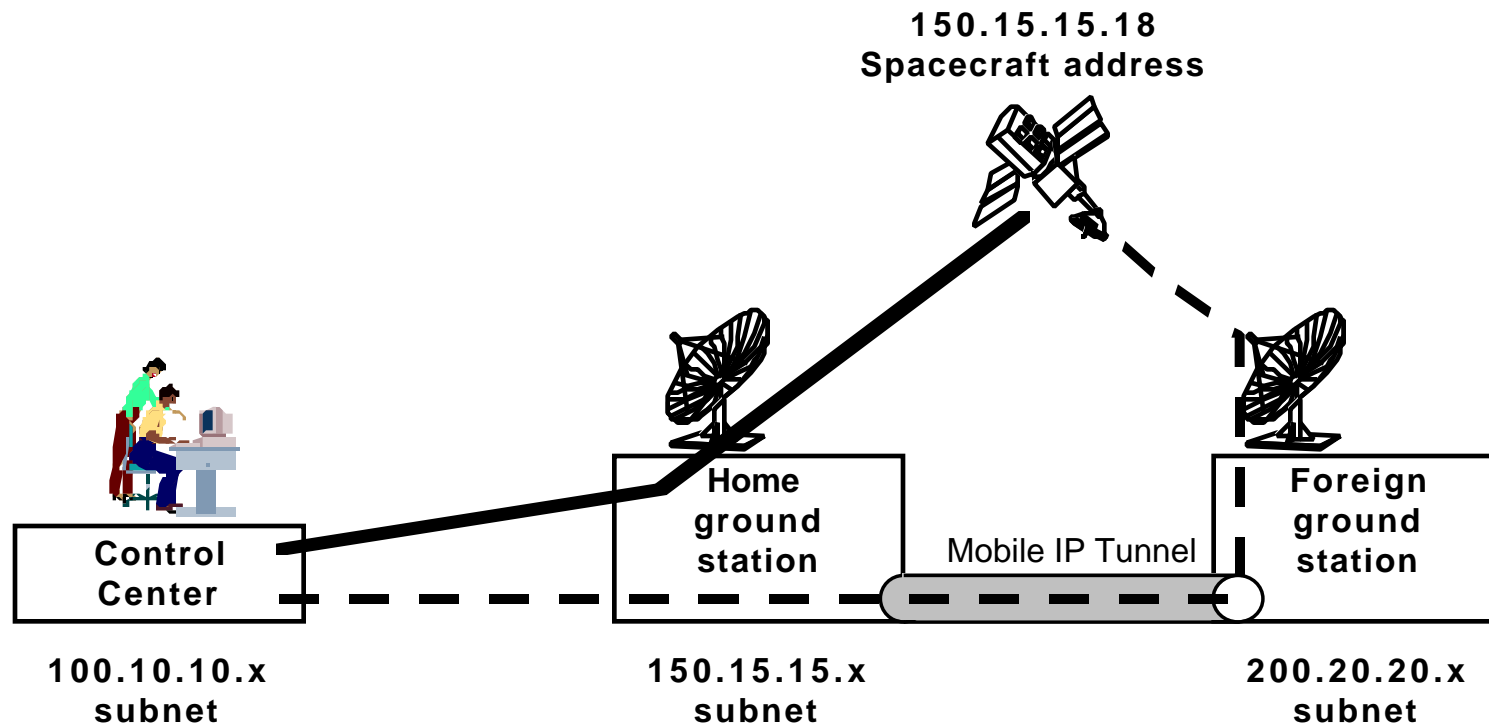
# Network Layer Issues



- **Long delay communication links**
  - IP is completely unaffected by delay
  - IP is simply addresses on the front of your data
  - IP needs no response and works fine to Pluto and beyond
- **Intermittent communication links**
  - IP has no concept of a “session” to be interrupted
  - Each packet contains full address information
- **Data priority**
  - IP has a Type of Service field
  - Routers support priority queuing by transport protocol and port
- **Overhead**
  - Lots of work on header compression due to Voice over IP and streaming video applications (RFC 2507, 2508 - 7 byte headers)

User Data Sizes (bytes)	100	500	1000	1400
IP (20)	16.6%	3.8%	1.9%	1.4%
UDP/IP (28)	21.8%	5.3%	2.7%	1.9%
TCP/IP (40)	28.5%	7.4%	3.8%	2.7%

- Downlink data is routed normally
- Mobile device registration with ground agents supports automatic uplink routing configuration





# Link and Network Summary



- **Simple network connectivity starts with changing S/C**
- **Use any modulation/coding/FEC to deliver bits**
- **Key issue is separation of coding from data-link framing**
- **Standard framing allows wide COTS usage on ground**
- **IP provides global addressing and connectivity**
- **Huge amount of R&D working on applying IP to communication environments much worse than spacecraft (e.g. cell phones, cars, wristwatches, etc.)**

**IP is not TCP !!!**

**OMNI - <http://ipinspace.gsfc.nasa.gov/>**